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EXCHANGE RISK - A CONCEPTUAL FRAMEWORK AND MEASUREMENT*

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Exchange Risk - A Conceptual Framework and Measurement

1. Introduction

This paper is an attempt at a better understanding of the phenomenon of exchange risk. Many writers in finance and economics have treated exchange risk in different contexts and from different points of view.[1] This paper centers around exchange risk providing both conceptual analysis and a model for empirical measurement.

The relevancy of exchange risk with regard to different subjects in international finance is discussed in section 2. In section 3, the different views of the structure of the international capital market, and thus on exchange risk are presented. Two possible sources for exchange risk, independent monetary policy and different rates of diffusion of changes in relative prices, are discussed in section 4. A model for the measurement of exchange risk is presented in section 5. The Interest Rates Parity Theorem is discussed in Section 6. Section 7 concludes this paper by discussing some suggestions for further research.

2. Is Exchange Risk Relevant?

Exchange risk, defined as the uncertainty associated with the future price of a unit of foreign currency in terms of a numeraire currency, is the main characteristic which makes the international capital market different than just an enlargement of a given domestic market. Thus exchange risk is relevant whenever one is interested in the unique international aspects of a given financial problem.

[illegible]

The relevancy of exchange risk both as an explanatory variable and as a part in the decision making process of firms is evident in security pricing in the international capital market, in the direction of international capital flows, in financial decisions, and thus the valuation of multinational corporations, and in discussing the riskiness of different systems of exchange rates.

Exchange risk is the only factor which makes the international security pricing model different from the model for a given domestic market. The existence of more than one currency brings about uniquely international risk factors, and, as was demonstrated by Solnik [17], the additional risk should be taken into account.[2] Other studies on international pricing of security were less explicit about exchange risk but a closer examination shows that they also take this type of risk into account even if by assuming that it is priced in the same way as other types of business risk.[3]

Exchange risk is cited by many writers as the dominating factor in international managerial finance.[4] In most of the studies the question is whether to use "self insurance" by bearing the risk involved in future changes in the exchange rates or to seek "market insurance" through either the forward exchange market or the money market. Exchange risk is frequently defined in this context in terms of accounting and the firm is assumed to respond to profits and losses as they are reported in the balance sheet and the profit and loss statement. Heckerman [7], [8], has looked into the relationship between the reported loss and the "real" loss in terms of future earnings and the value of the firm but both his analysis and the more traditional approach regard exchange risk from a partial equilibrium, single-firm point of view. A better understanding of exchange risk in a general equilibrium

context may improve the decision-making process mentioned above. To the extent that such an overall view of exchange risk can show how shareholders are expected to evaluate exchange risk given their portfolios, this information should affect the behavior of the multinational firms.

Although most practitioners would cite exchange risk as one of the dominating factors affecting capital flows, in particular, capital flows to developing countries, it is not explicitly treated as such in the literature.[5] Exchange risk is relevant in the context of international capital flows both as an explanatory variable and as a policy variable. Given a proper measurement of the systematic effects of exchange risk, international capital flows can be explained on the basis of portfolio adjustment.[6] What may be even more relevant, however, is to examine how exchange risk should affect the policy of attracting foreign capital flows a policy common to most of the developing countries. Traditionally exchange risk was regarded as one of the main barriers to capital flows to those countries, but given the nature of exchange risk as discussed in section 4 below it may prove as a much lower barrier and, in some extreme cases, even a stimulant to foreign investment.

The recent rapid changes in the exchange rates system and the coexistence of both pegged and flexible exchange rates brought up again the discussion on the relative merits of the different systems. One of the relevant issues is which of the two competing systems is riskier in terms of the associated exchange risk to traders and investors.[7]

3. Exchange Risk and the Structure of the International Capital Market - The Different Views on Market Imperfections

Exchange risk is not a phenomenon associated with perfect capital markets. Thus the different views on the nature of market imperfections are in the roots of the different views on exchange risk.

In a perfect capital market with no transaction costs, it is difficult to explain the role of money, let alone the existence of several currencies. Even if one allows for different currencies for some political reasons , the Purchasing Power Parity will hold, the relation among different currencies will be similar to those among bills of different denominations.[8] Given some price changes in one country, all changes in the exchange rates of others countries' currencies and the country in which the change was originated are fully anticipated and given by the Purchasing Power Parity theorem.

Exchange risk could be explained on the basis of some barriers for the movements of goods or capital assets or information with regard to price changes. Barriers can be in the form of transportaion costs, taxes, cost of information or some institutional arrangements.

Solnik [17], [18], in one of the most explicit and complete analyses of exchange risk has assumed localized consumption. Consumers in different geographical locations were said to behave as if they could consume only locally produced goods.[9] This assumption implies a complete barrier on the movements of goods, and makes all commodities non-tradeables.

Adler [1] has assumed that investors in one country are barred from owning capital assets in another country and "The one macro-constraint is that, while capital is free to flow from 0 to 1 (countries), no capital funds can be raised in 1 for use in 0."[10]

In a recent paper, Black [5] has suggested that exchange risk can be treated as if it is a differential tax rate levied on different groups of investors according to their location. Aliber [4] viewed exchange risk as a short-term deviation from the long-term equilibrium suggested by the Purchasing Power Parity theorem.

Implicit assumptions about the kind of market imperfections which give rise to exchange risk can be derived from the more managerial oriented articles which center around the measurement of the firm exposure to exchange risk in accounting terms. Shapiro [16] and Heckerman [7], [8] imply some deviations from the perfect market, equilibrium approach where the Purchasing Power Parity will hold instantaneously.

There is abundant evidence to show that all the above mentioned market imperfections do exist in reality. Economic models, however, are not judged by their precise description of the reality as much as by their providing a base for a better understanding of economic behavior. Different models may be useful to understand different aspects of exchange risk. In the next section, one more model is presented in an attempt to gain better insight into the phenomenon of exchange risk.

4. Independent Monetary Policy, a Stochastic Diffusion Process and Exchange Risk

Assume a multicountry world. There are N countries and n currencies. The legal tender in country J, J = 1,2,..., N is currency j, j = 1,2,...,n. Returns originated in country J are denominated in terms of currency j. One country country 1 is assumed to be the large country, all other countries, J = 2,3,...,N, are small countries. All commodities are assumed to be tradeable, and there are no barriers to the free movements of commodities.

There are two possible sources for exchange risk in this world: independent monetary policy in the small country (independent from the monetary policy of the large country), and a stochastic diffusion process associated with the transmission of information on price changes in the large country.

Given standard assumptions on large and small countries, the currency of the large country is assumed to be the perfect proxy for a perfect index of world-wide consumption. In the long run the world's price level is determined by the rate of monetary expansion of the large country. Exchange risk, in such a world, is defined as the uncertainty associated with the future price of the currencies of the small countries in terms of the large country's currency.

Small countries can maintain, at least for a while, an independent monetary policy. Such a policy would lead to two types of uncertainty with regard to the future price of the currencies of the small countries in terms of the standard currency, currency 1. The first stochastic process has to do with the length of time in which the monetary authorities of a given small country will maintain the independent monetary policy, the second process has to do with the effects of such a policy which are highly uncertain.[11]

The second possible source of exchange risk in such a world has to do with an uncertain rate of diffusion of price changes. The different rates of diffusion may reflect institutional as well as physical barriers to the flow of information.

One possible way to capture the uniqueness of investing in the small country, a uniqueness reflecting one or all of the stochastic processes described above, is by dividing the stream of income associated with a particular investment in the small country into two parts:

(a) The economic activity - this part is defined by assuming a perfect capital market in equilibrium.

(b) The small country effect - this part is defined by looking at the actual returns under the existing imperfect market conditions.

Let P_{i1t} be the price of security i at country 1, the large country at time t. $i = 1,2,\ldots, I$ denotes economic activities.[12] P_{i1t} is denominated in the currency of country 1.

Let P_{ijt} be the price of security i, a comparable economic activity in a given small country, $J = 2,3,\ldots N$ at time t. P_{ijt} is denominated in terms of currency j, $j = 2,3,\ldots n$. A security in a given small country is defined as comparable or similar to a security in the large country if given a perfect capital market in equilibrium they belong to the same risk class.[13] Thus given a perfect capital market and an instantaneous adjustment, the return of two such securities are perfectly correlated.

By buying a security in risk class i denominated in currency j and selling short security in risk class i in currency 1, the investor obtains a J country security which by definition reflects the unique uncertainty

associated with the country, and thus captures the special characteristics of doing business in country J. Following the argument presented above this derived security reflects the exchange risk of that particular country.

By varying the maturity of the short in the large country the investor can determine the time horizon of its small country asset. Essentially the investor has borrowed money at risk class i and invested it in a combination of risk class i and a risky rate associated with currency j. The net effect on the portfolio is that of the small country asset j.

A matrix of the prices of foreign investment assets can be specified as follows:

$$
\begin{array}{c|ccccc}
\text{maturity} \backslash \text{currency} & 2 & \cdots & j & \cdots & n \\
\hline
1 & {}_{o}P_{1,2} & & {}_{o}P_{1,j} & \cdots & {}_{o}P_{1,n} \\
2 & {}_{1}P_{2,2} & & {}_{1}P_{2,j} & & {}_{1}P_{2,n} \\
\vdots & \vdots & & \vdots & & \vdots \\
t & {}_{t-1}P_{t,2} & & {}_{t-1}P_{t,j} & & {}_{t-1}P_{t,n} \\
\vdots & \vdots & & \vdots & & \vdots \\
T & {}_{T-1}P_{T,2} & & {}_{t-1}P_{T,j} & & {}_{T-1}P_{T,n}
\end{array}
$$

where the general expression, ${}_{t-1}P_{t,j}$ is derived as follows:

$$
{}_{t-1}P_{t,j} = {}_{t-1}P_{ijt-1} - {}_{t-1}P'_{ilt}
$$

where ${}_{t-1}P'_{i1t}$ is the short price for one period of a security in risk class i in currency 1 at time t-1. In principle, ${}_{t-1}P_{t,j}$ can be derived from any given risk class i.[14] An important implication of this model is that whenever an investor is buying a capital asset denominated in terms of a small country currency, he is buying a combination of assets. A part of what he buys is a perfect substitute to capital assets traded in the market of the large country and only a part of the income stream is associated with the small country risk.

Given that all investors use the same consumption index and the same currency as a proxy for consumption, they will view all the small country assets as risky regardless of their own location. The pricing of this risk depends, however, on the correlation between the returns on the small country assets and the world portfolio or some other measure for systematic risk. This and other measurement problems are discussed in the following section.

5. The Small Country Investment Asset A Model for the Measurement of Exchange Risk

The definition of a small country asset and exchange risk described in the last section was based on the ability to classify capital asset by risk classes under conditions of equilibrium and a perfect capital market. Exchange risk was then measured by the deviations from this equilibrium at any point in time, t. Unfortunately, this is an abstract exercise with no empirical content. However, one implication of the generalized, abstract model can be utilized to enable the specification of empirically measurable statements.

Given the model, securities in the small countries were viewed as combinations of some economic activity and the small country asset. An empirical measurement can be constructed if there are some activities which, given a perfect market and equilibrium are expected to be identical. One such activity is the pure time preference reflected by the riskless rate. In a perfect market there is only one riskless rate, so any differences in the pricing of riskless securities in the different countries must reflect the unique factor associated with this country, i.e. the small country asset.

Traditionally the riskless rate is measured over one period and thus the risk associated with the multiperiod nominal rate is avoided. This convention is used in the literature on the Interest Rates Parity Theorem as well. To justify the more general specification used here one has to adopt one of the following two assumptions:

(a) The underlying relationships between multiperiod riskless rates and the comparable future one period rates are the same in the large and in the small countries. In this case, once a decision is taken with regard to the desired maturity the risk associated with the long position is the same over all the countries.

(b) Long-term instruments are of the variable rates type. Such instruments are becoming more and more popular now. (For example, the London InterBank Offer Rate adjustment in the Eurodollar market.)

Let ${}_{\tau-t}P_{f1\tau}$ be the unit price of a riskless asset in currency 1 at time t with time to maturity τ periods hence. Let ${}_{\tau-t}P_{fj\tau}$ be the unit price of a comparable asset in currency j at time t with time to maturity τ periods hence. (Comparable asset means that the asset is riskless in terms of currency j). Any investor can acquire a small country j asset for τ periods by issuing a riskless asset in currency 1 (borrowing in 1) and simultaneously buying the j currency riskless asset, where both assets have the same maturity. The investor now owns a small country asset of country (and currency) j for τ periods. The unit price of this asset is:

$${}_{\tau-t}P_{j,\tau} = {}_{\tau-t}P_{fj\tau} - {}_{\tau-t}P_{f1\tau}$$

By varying τ, $\tau = 1,2,\ldots,T$ a term structure of the small country asset j can be obtained. The measurement of the exchange risk, or the temporal price structure of the small country asset will enable empirical tests of different hypotheses with regard to the sources of that risk. Also by deriving the small country asset in the capital market rather than in the forward exchange market, it is possible to extend the term structure into the long term whereas price quotations for forward exchange contracts are limited to one year at the most.

The systematic component of the risk associated with the small country can be estimated by relating the measured exchange risk for a given country to the relevant market index.

6. The Interest Rates Parity Theorem - Market Insurance and Exchange Risk

The relationship between the forward exchange market and the two relevant money markets is postulated by the Interest Rates Parity Theorem (IRPT)[15]. IRPT is usually presented by the following equation:

$$\frac{F_{jt} - S_{jt}}{S_{jt}} = \frac{i^1 - i^j}{1 + i^j}$$

where F_{jt} and S_{jt} are the one period forward and spot exchange rates between currencies 1 and j. i^1 and i^j are the one period riskless rates of interest in terms of currencies 1 and j respectively. By adding and subtracting 1 to the numerator the equation shown above becomes:

$$\frac{F_{jt} - S_{jt}}{S_{jt}} = \frac{(1 + i^1)-(1 + j^j)}{1 + i^j}$$

As $1 + i^1$ can be expressed as ${}_{t}P_{f1t+1}/{}_{t-1}P_{f1t}$ and $1+i^j$ as ${}_{t}P_{fjt+1}/{}_{t-1}P_{fjt}$ IRPT can be respecified in price relative terms as follows:

$$\frac{{}_{\tau-t}P_{j,\tau}}{{}_{\tau-t-1}P_{j,\tau-1}} = \frac{{}_{\tau-t}P_{f,j\tau}}{{}_{\tau-t-1}P_{fj\tau-1}} - \frac{{}_{\tau-t}P_{f,1\tau}}{{}_{\tau-t-1}P_{f,1\tau-1}}$$

The last two equations imply that given a forward exchange market, a small country asset for any country j can be obtained either through forward transaction or through the capital market as was described in section 5 above. Given the term structure of the small country asset the IRPT can be extended beyond the traditional one period case.

By using the forward exchange market or the capital market, an investor can sell off the small country risk (or the exchange risk) associated with a capital asset traded in the market of a small country. This is comparable to buying insurance in the market. The IRPT measures the required premium for such an insurance. Given the current models for the pricing of risk in the market, this premium will be associated with the systematic component of the insured risk. The deviations from the IRPT are not a measure for the exchange risk as much as a measurement for the efficiency of the arbitrage process involved in this operation.

7. Conclusions and Suggestions for Further Research

Exchange risk is a relevant and important component of many subjects in international finance. A better understanding of the nature and the probable causes of exchange risk may contribute toward a better explanation of observed phenomena as well as to better policy recommendations.

As exchange risk is shown to be an imperfect market phenomenon, it is important to specify the nature and the reasons for the assumed imperfections.

Given an economic model which purports to explain the basic risk associated with a particular small country in a measurable way and the market measurement of such risk as proposed in this paper, a testable hypothesis with regard to the pricing and the quantity of this risk can be formed. Then the effect of different international financial arrangements such as exchange rate policies, commercial policies, and policies of multinational corporations can be evaluated and better understood.

Footnotes

1. See, for example, Solnik [17] and Black [5] with regard to security pricing; Adler [1] and Aliber [4] with regard to behavior of multinational firms; Lietaer [10] with regard to a model for the management of exchange risk.

2. The Solnik model, however, is only one possibility to account for exchange risk. Other models are discussed later on.

3. See Agmon [2].

4. For example, see Aliber [4], Robbins and Stobaugh [15], Weston and Sorge [19].

5. See Onitsuka [14]. Also many practitioners regard exchange risk in developing countries as a part of a more general phenomenon known as political risk.

6. For example, see Lee [9].

7. One of the traditional arguments against flexible exchange rates is that this system is riskier to traders and investors than the pegged exchange rates system. Given the nature of exchange risk as discussed in the following section, the opposite may be true.

8. For a discussion of the Purchasing Power Parity theorem, see Aliber [3].

9. Solnik [17], p.16, A8.

10. Adler [1], p.124.

11. A dynamic system of adjustments in a multicurrency world is discussed by Mundell [12].

12. In some cases, economic activities may be identified with industries, especially where industries are homogeneous. In most cases, however, the standard classification of an industry includes several economic activities.

13. The notion of a risk class was introduced by Modigliani and Miller [11]; a more recent definition is in Fama and Miller [6], p.161.

14. For an empirically measurable model, see section 5 below.

15. For a survey and a discussion of the IRPT, see Officer and Willet [13].

References

1. Adler, M. "The Cost of Capital and Valuation of a Two-Country Firm," The Journal of Finance, March 1974.
2. Agmon, T. "The Relationship Among Equity Markets: Reply," The Journal of Finance, September 1974.
3. Aliber R.Z. "Equilibrium and Disequilibrium in the International Money Market," Mimeo. The University of Chicago, 1974
4. Aliber, R.Z. "Economics of Corporate Exchange Risk," Unpublished manuscript, The University of Chicago, 1974.
5. Black, F. "International Capital Market Equilibrium with Investment Barriers" mimeo, Graduate School of Business, The University of Chicago July 1974.
6. Fama, E.F. and Miller, M.H. The Theory of Finance, Holt, Rinehart and Winston, 1972.
7. Heckerman, D.G. "The Exchange Risks of Foreign Operations," The Journal of Business, January 1972.
8. Heckerman, D.G. "On the Effects of Exchange Risk," Journal of International Economics, 3, 1973.
9. Lee, C.H. "A Stock Adjustment Analysis of Capital Movements: The United States Canadian Case," Journal of Political Economics, July/August, 1969.
10. Lietaer, B. "Managing Risks in Foreign Exchange," Harvard Business Review, March-April, 1970.
11. Modigliani, F. and Miller M.H. "The Cost of Capital, Corporation Finance, and the Theory of Investment" American Economic Review, June, 1958.
12. Mundell, R.M. International Economics, McMillan, 1968, Ch. 21.
13. Officer, L.H. and Willet, T.D. "The Covered Arbitrage Schedule: A Critical Survey of Recent Developments," Journal of Money,Credit and Banking, 1970.
14. Onitsuka Y. "International Capital Movements and the Pattern of Economic Growth" The American Economic Review, March 1974.
15. Robbins, S.M. and Stobaugh R.B. Money in the Multinational Enterprise: A Study in Financial Policy, Basic Books, 1973.
16. Shapiro A.C. "Exchange Risk and the Multinational Corporation," Mimeo, The Wharton School, University of Pennsylvania.

17. Solnik, B.H. European Capital Markets, Heath, Lexington Books, 1973.

18. Solnik, B.H. "An Equilibrium Model of the International Capital Market," Journal of Economic Theory,

19. Weston, F. and Sorge, B. International Managerial Finance, Irwin, 1972.

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